NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Subsurface Drain

(Feet)

Code 606

DEFINITION

A conduit, such as corrugated plastic tubing, tile or pipe, installed beneath the ground surface to collect and/or convey drainage water.

PURPOSES

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:

   a. regulating the water table and ground water flows,
   b. intercepting and preventing water movement into a wet area,
   c. relieving artesian pressures,
   d. removing surface runoff,
   e. leaching of saline and sodic soils,
   f. serving as an outlet for other subsurface drains, and
   g. regulating subirrigated areas or waste disposal areas.

2. Collect ground water for beneficial uses.

3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.

4. Regulate water to control health hazards caused by pests such as liver fluke, flies, or mosquitos.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas having a high water table where the benefits of lowering the water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged. Septic tanks and other waste disposal systems shall not be connected directly to subsurface drain systems.

CRITERIA

The design and installation shall be based on adequate surveys and investigations.

Capacity. The required capacity shall be determined by one or more of the following:

1. Application of drainage coefficients, as recommended by the Indiana Drainage Guide or Chapter 14, Part II of the Engineering Field Manual (EFM), to the acreage drained, including added capacity required to dispose of surface water entering through surface inlets.

2. Yield of ground water based on the expected deep percolation of irrigated water from the overlying fields, including the leaching requirement.

3. Comparison of the site with other similar sites where subsurface drain yields have been measured.

4. Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.

5. Application of Darcy's law to lateral or artesian subsurface flow.

6. Estimates of lateral or artesian subsurface flow.

Size. The size of subsurface drains shall be computed by applying Manning's formula. The size shall be based on the required capacity and computed by using one of the following assumptions:

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.

2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.

3. Conduit flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

All subsurface drains shall have a nominal diameter that equals or exceeds three inches. Unless special bedding arrangements are provided, the minimum diameters used in organic soils shall be five inches for plastic tubing and six inches for rigid tile. Rigid tile used in organic soils shall have a minimum length of two feet.

Existing subsurface drains used for outlets. When an existing subsurface drain is to be used for an outlet, the following shall apply:

CASE 1 – For areas to be drained that are five (5) acres or less.

This will apply principally to small systems and random lines where complete extensive systems are not needed.

An investigation shall be made of the existing subsurface drain to determine that:

1. It is in good physical condition based on observations at the junction point with the new system.

2. It has adequate capacity based on general observations made in the field. A survey or instrument check of the subsurface drain main downstream a distance of 200 to 300 feet from the junction is advisable to determine grade. It will not be necessary to continue this check to the outlet unless observations indicate the advisability of such survey.

3. It has sufficient depth to provide minimum cover for all new lines to be installed.

CASE II – For areas to be drained in excess of five (5) acres.

The investigation shall include the following:

1. A physical inspection of the existing subsurface drain to determine that it is operative, free from breakdowns, and has an adequate outlet. The physical inspection will constitute observing the physical condition of the subsurface drain for the following conditions:

a. Breakdowns which are usually accompanied by holes in the land over and along the line.

b. Fractured tile, such as quartering (fractures on the quarter points, which result in an egg-shape cross-section).

c. Deposition of soil. If excessive deposition appears, make a further study to determine the cause and correct the situation.

d. Physical material deterioration that would seriously subject it to failure, due to high absorption rate, soil acidity, or alkalinity, etc.

2. Determine the capacity of the existing tile by checking the grades and sizes in the critical areas, particularly the flat reaches.

3. The existing subsurface drain outlet will be considered adequate if the capacity of the subsurface drain, as determined in Step 2, is greater than 80% of the required capacity, and if the existing tile is not deteriorated because of holes, quartering, roots or submergence of the outlet, except where such damages are repaired, and/or corrected.

If the surface drain is a drain of record or legal drain, all the information available from the record, should be used in making the determination as to the adequacy of the tile outlet.

Depth, spacing, and location. The depth, spacing, and location of the subsurface drain shall be based on site conditions, including soils, topography, ground water conditions, crops, land use, and outlets.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet or sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel. Depth of mains should be designed so that the laterals can be joined to the main with a center-to-center or higher connection. A minimum difference in elevation of 0.3 foot between the flow lines of the main and of the lateral is desirable. Flowline-to-flowline connection is permissible when unavoidable.

The minimum depth of cover in organic soils shall be 2.5 feet for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table in organic soils within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Heavy duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. The design load on the conduit shall be based on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 feet. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Recommendations for depth, spacing, and location area provided in the Indiana Drainage Guide and Chapter 14, Part II of the EFM.

Maximum velocity and grade. In areas where sedimentation is not a hazard, the minimum grades shall be based on site conditions and a velocity of not less than 0.5 foot per second. If a hazard exists, a velocity of not less than 1.4 feet per second shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions.

Velocities based upon drain material sizes and grades are shown on the applicable nomographs

in both the Indiana Drainage Guide and Chapter 14, Part II of the EFM.

Maximum velocity without protection.

Excessive flow velocity in the drain may induce piping of soil material into the drain line.

Maximum velocities by soil texture:

Soil texture	Velocity feet/second
Sand and sandy loam ……..	3.5
Silt and silt loam ……..…	5.0
Silty clay loam ……	6.0
Clay and clay loam …….	7.0
Coarse sand or gravel ……..	9.0

Maximum grade and protection.

On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated under "Maximum velocity without protection," special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site.

The protective measures shall include one or more of the following:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.

2. Use nonperforated continuous tubing, a watertight pipe, or sealed joints.

3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.

4. Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.

5. Wrap open joints of pipe or tile with tar-impregnated paper, burlap, or special fabric-type filter material.

6. Install open air risers for air release or entry.

Iron ochre considerations.

If drains are to be installed in sites where iron ochre problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron is in its insoluble form.

Where possible, in areas where the potential for ochre problems is high, protection against ochre development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection against root clogging.

Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water-loving trees, such as willow, cottonwood, elm, and soft maple or some shrubs and grasses growing near sub-surface drains may enter and obstruct the flow.

The first consideration is to use nonperforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 feet on each side of the drain. A distance of 50 feet should be maintained from other species of trees except for fruit trees. Drains located close to fruit trees can often be used to drain orchards.

Where crops and grasses may cause trouble on drain lines, facilities may be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drainlines to prevent growth into the system.

Materials

Subsurface drains include conduits of plastic, clay, concrete, bituminized fiber, metal, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site. All conduits shall meet or exceed the minimum requirements indicated in the Materials section of the construction specifications.

Foundation

If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by using long sections of perforated or watertight pipe having adequate strength to insure satisfactory sub-surface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing.

Filters and filter material

Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. A suitable filter should be specified if:

(1) local experience indicates a need,

(2) soil materials surrounding the conduit are dispersed clays, low plasticity silts, or fine sands (ML or SM with P.I. less than 7);

(3) where deep soil cracking is expected; or

(4) where the method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation will be based on the gradation of the base material surrounding the conduit within the following limits:

D_{15}size smaller than 7 times d_{85} size, but not smaller than 0.6 mm;

D_{15} size larger than 4 times d_{15} size; less than 5% passing No. 200 sieve; maximum size smaller than 1.5 inches.

D represents the filter material and d represents the surrounding base material.

The number following each letter is the percent of the sample, by weight, that is finer than that size. For example, D_{15} size means that 15 percent of the filter material is finer than that size.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material except that the top of the conduit and side filter material may be covered by a sheet of plastic or similar impervious material to reduce the quantity of a filter material required.

Artificial fabric or mat-type filter materials may be used provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

Envelopes and envelope material

Envelopes shall be used around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM-C-33 fine aggregate for

concrete has been satisfactorily used and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Placement and bedding

The conduit should not be placed on exposed rock or stones more than 1.5 inches in diameter. Where such conditions are present the trench must be overexcavated a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to insure proper alignment. If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or a silt slurry.

For trench installations of corrugated plastic tubing 8 inches or less in diameter, one of the following bedding methods will be specified.

1. A shaped groove or 900 V-notch in the bottom of the trench for tubing support and alignment.

2. A sand-gravel envelope, at least 3 inches thick, to provide support.

3. Compacted soil bedding material beside and to 3 inches above the tubing.

For trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations should be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 inches in diameter. Blinder should be carried to a minimum of 3 inches above the conduit.

Auxiliary structures and protection

Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

If the drain system is to carry surface water flow, the capacity of the surface water inlet shall not be greater than the maximum design flow in the drain line or lines. Covers and/or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

The capacity of a relief well system will be based on the flow from the aquifer, the well spacing, and other site conditions, and will be adequate to lower the artesian waterhead to the desired level.

The size of relief wells is generally based on available materials rather than on hydraulic considerations. Such wells will not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 feet will be provided in either circular or rectangular structures.

The drain system must be protected against velocities exceeding those provided under

"Maximum velocity without protection" and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1.5 feet of soil cover.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting cap of the same material as the conduit or other durable materials.

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. Where tubing is connected to old tile lines that may serve as animal runs, an animal guard should be installed within the line to restrict animal travel. Automatic flap gates, horizontal rods, or similar protection shall be used on all drain outlets to exclude small animals. No fixed bar or other type grating should be used where direct entry of surface water or any type debris is possible. Gates should be used in these cases. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the outlet section. Minimize the visual impact of projecting outlets.

When discharging a subsurface drainage system into a pond or lake, the minimum elevation of the outlet pipe invert shall be at the normal level of the pond or lake. When the outlet is located near an area of sediment deposition along the shoreline, the minimum elevation of the outlet pipe invert shall be at least 1.0 feet above the normal water elevation.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to the standards for Regulating Water in Drainage Systems (554) or Water Table Control (641).

The outlet pipe and its installation will conform to the following requirements:

1. If burning vegetation on the outlet ditch bank is likely to create a fire hazard, the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.

2. Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side slope protected from erosion. The minimum length of the pipe will normally be 8 feet. Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1:1 or less) with a narrow bottom width of 3 feet, commonly referred to as "minimum ditches, for outletting individual subsurface drain laterals. For conduits 10 inches or greater, longer outlet sections should be considered such as:

10 inches and 12 inches in diameter, use 12 feet;

15 inches and 18 inches in diameter, use 16 feet;

Use 20-feet outlet pipe for all diameters larger than 18 inches.

3. If ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered part of the pipe will be protected from the current in the ditch.

4. Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid wash-outs and other failures.

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under ditches or other structures. Conduits under roadways must be designed to withstand the expected loads. Shallow subsurface drains through depressed or low areas and near outlets must be protected from damage caused by farm machinery and other equipment, and from freezing and thawing.

CONSIDERATIONS

Consideration shall be given to maintaining and enhancing environmental values and visual resources where applicable. The landowner/user will be advised if wetlands will be affected and that USDA/NRCS wetland policy shall apply. All work planned shall be in compliance with General Manual Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations.

Consideration shall be given to possible damages above and below the point of discharge that might involve legal actions under state or local laws.

The effects on water quantity and quality shall be considered.

Water Quantity. Base flow and interflow may increase because excess soil water is removed from the field by lowering the water table. Effects on recharge vary with geohydrologic conditions of the area because ground water at one location may be picked up and delivered to another location that will allow recharge. Intercepting the soil water may decrease deep percolation in the field being drained, and reduce ground water recharge. Evaporation may decrease in the drained field if ponded surface water is removed. Changes in plant water requirements, because of increased growth, may increase transpiration.

Water Quality. Soil water outletted to surface watercourses by this practice may be low in concentrations of sediment and sediment-absorbed substances that may improve stream water quality. Sometimes the drained soil water is high in the concentration of nitrates and other dissolved substances that may exceed drinking water standards. If drainage water that is high in dissolved substances is able to recharge ground water, the aquifer quality may also become impaired. Stream water temperatures may be reduced by drainage water discharge. Aquatic habitat may be altered or enhanced with the cooler water temperatures.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction specifications

General. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife will be used where practical. Trees, stumps, and brush removed from the construction area may be piled for wildlife habitat when approved by the landowner/user.

The completed job shall present a workmanlike appearance and shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field and according to manufacturer's recommendations.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

The installing contractor shall certify that the installation complies with the requirements of these specifications. The contractor shall also name the source of materials.

Installation

Inspecting and handling materials. Materials for subsurface drains shall be carefully inspected before the drains are installed. This applies to pre-certified materials as well. Plastic pipe and tubing shall be protected from hazard-causing deformation or warping. Plastic pipe and tubing with physical imperfections shall not be installed. A damaged section shall be removed and a suitable joint made connecting the retained sections. Clay and concrete tile shall be checked for damage from freezing and thawing before it is installed. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

Materials

The following specifications pertain to products currently acceptable for use as subsurface drains. These specifications are also to be applied in determining the quality of materials referenced by other standards:

Type Specification

Plastic

Corrugated polyethylene (PE) tubing and fittings 3-6 in ---------- ASTM-F-405[1]
Corrugated polyethylene (PE) tubing and fittings 8-24 in ---------- ASTM-F-667[1]
Corrugated polyvinyl chloride (PVC) tubing and compatible fittings - ASTM-F-800[1]
Polyvinyl chloride (PVC) corrugated sewer pipe with a smooth interior and fittings 4-8 in ---------- ASTM-F-949[1]
Polyvinyl chloride (PVC) sewer pipe and Fittings ---------- ASTM-D-2729[1] or D-3034 type PSM or PSP

Clay

Clay drain tile ---------- ASTM-C-412[1]
Clay drain tile, perforated ------- ASTM-C-498[1]
Clay pipe, perforated, standard and extra strength ---------- ASTM-C-700[1]
Clay pipe, testing ---------- ASTM-C-301[1]

Concrete

Concrete drain tile ---------- ASTM-C-412[1]
Concrete pipe for irrigation or drainage ---------- ASTM-C-118[1]
Concrete pipe or tile, determining physical properties of ---------- ASTM-C-497[1]
Concrete sewer, storm drain, and culvert pipe ---------- ASTM-C-14[1]
Reinforced concrete culvert, storm drain, and sewer pipe ---------- ASTM-C-76[1]
Perforated concrete pipe ---------- ASTM-C-444[1]
Portland cement ---------- ASTM-C-150[1]
Pipe, corrugated (aluminum alloy) Federal Specification WW-P-402[2] Pipe, corrugated (iron or steel, zinc coated) ---------- WW-P-405[2]

[1] Specifications can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

[2] Specifications can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Conduit perforations special requirements

Where perforated conduit is required, the water inlet area shall be at least 1 square inch per foot of conduit length. Round perforations shall not exceed 3/16 inches diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of ½ inch may be used. Slotted perforations shall not exceed 1/8 inch in width.

Protection against root clogging. All water-loving trees such as willow, elm, soft maple, and cottonwood should be removed for a distance of 100 feet on each side of the subsurface drain. A distance of 50 feet should be maintained from other species of trees, shrubs, or vines. If the trees cannot be removed or the line rerouted, a closed line with sealed joints should be installed. This type of construction should extend throughout the tree root zone.

Specifications-flexible conduit

General requirements. All conduits shall be laid to line and grade in such a way that the side walls are continuously and uniformly supported with suitable bedding material. Such material shall be properly placed and compacted to provide lateral restraint against deflection and to protect the conduit against collapse during backfilling.

Trenching. Trench widths must be adequate for proper installation of the conduit, allow proper joining of sections; and allow proper placement of filter, envelope, or blinding materials. The trench bottom shall be constructed to proper grade before placement of the conduit.

Where rock is encountered the trench will be overexcavated minimum of 6 inches and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

Plow installation. Plow installation has been satisfactorily used in many situations. Special care needs to be exercised relative to grade control and bedding conditions.

Bedding. The trench bottom shall be smooth and free of clods and loose or exposed rock. Where a gravel envelope is not specified, the bottom of the trench shall be shaped to conform to the pipe. The groove may be semi-circular, trapezoidal, or a 90 degree "V" shape (90 degree "V" suitable for 3-8 inches only) and shall be of such dimensions that the bottom quarter of the pipe is below the contact points of the groove.

In unstable soils a firm foundation shall be provided by overexcavation and backfilling with processed stone or gravel, suitably graded so as to act as a mat into which unstable soil will not penetrate.

Filters and envelopes. If a sand-gravel filter is specified, it shall be clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1.5 inches.

Placement. Conduit will be placed in such a way that maximum stretch does not exceed 5 percent.

Fittings shall be installed in accordance with instructions furnished by the manufacturer. Couplers are recommended at all joints and fittings, at all changes in direction (where the centerline radius is less than three times tubing diameter), at changes in diameter, and at junction with another line.

Caps are needed at the ends of lines. All fittings shall be compatible with the tubing. Where certain fittings are not available, hand cut holes are acceptable provided care is taken when making the connection not to create a means of obstructing flow, catching debris, or allowing soil to enter the line. Place selected bedding material, containing no hard object larger than 1.5 inches in diameter in the trench to a minimum depth of 6 inches over the conduit. The conduit will be held in place mechanically until secured by blinding.

Backfilling. Place backfill material so that displacement or deflection of the conduit will not occur. This is preferably on an angle, so the material flows down the front slope. Avoid large stones, frozen material, and dry clods that cause concentrated point loads on the tubing. The trench should be backfilled as soon as practical. When installing the tubing on a hot day, backfilling should be delayed until tubing temperature cools to the soil temperature.

Specifications – clay and concrete tile.

Clay and concrete drain tile special requirements. If clay tile will not be exposed to freezing and thawing before or during installation and if the average frost depth will be less than 18 inches, the freezing and thawing and absorption tests may be modified or waived.

The use of concrete tile in acid and sulfate soils shall be in accordance with the following limitations:

Acid soils:

Class of tile	Lower permissible limits of pH values: Organic and sandy soils	Medium and heavy-textured soils
ASTM-C-412		
Standard quality	6.5	6.0
Extra quality	6.0	
Heavy duty extra quality	6.0	5.5
Special quality	5.5	
ASTM-C-14		
C-118, C-444	5.5	

NOTE: Figures represent the lowest reading of pH values for soil or soil water at subsurface drain depth.

Sulfate soils:

Type of tile and cement (minimum)	Permissible maximum Limit of sulfates, singly or in combination p/m
Tile: ASTM-C-412 Special quality C-14, C-118, C-444	7,000
Cement: ASTM-C-150, Type V	
Tile: ASTM-C-412 Extra quality Heavy-duty extra quality C-14, C-118, C-444	3,000
Cement: ASTM-C-150, Type II or V	
Tile: ASTM-C-412 Standard quality C-14, C-118, C-444	1,000
Cement: ASTM-C-150, any type	

Note: Figures represent the highest reading of sulfates for soil or soil water at subsurface drain depth.

Bell and spigot, tongue and groove, and other types of pipe that meet the strength, absorption, and other requirements of clay or concrete tile as specified in the preceding paragraphs, except for minor imperfections in the bell, the spigot tongue, or the groove, and ordinarily classed by the industry as "seconds", may be used for drainage conduits, provided that the pipe is otherwise adequate for the job.

Trenching. Trench widths must be adequate for proper installation of the conduit; must allow proper joining of sections; and must allow proper placement of filter, envelope, or blinding materials. The trench width will allow a minimum of 3 to 6 inches on both sides of tubing. The trench bottom shall be constructed to proper grade and shape before placement of the conduit.

Where rock is encountered the trench will be overexcavated a minimum of 6 inches and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

Bedding. If unstable soil conditions are encountered, the trench bottom must be stabilized before placement of conduit. Where necessary, the unstable material will be removed and replaced with sand-gravel or a similar suitable stabilizing material. Where an envelope is not specified, the bottom of the trench shall be shaped to ensure good alignment of the conduit. Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded. When completed, the conduit shall be a minimum of 6 inches from rock.

Filters and envelopes. If a sand-gravel filter is specified, it shall be clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1.5 inches. ASTM-C-33 fine aggregate for concrete will meet these requirements.

Placement. All conduits shall be laid to line and grade and covered with the specified blinding, envelope, or filter material to a depth of not less than 3 inches around the drain. Blinding material shall contain no hard objects larger than 1.5 inches in diameter.

When a sand-gravel filter is specified, all openings in the conduit must be covered with at least 3 inches of filter material except that the top of the conduit and the side filter material may be covered with a sheet of plastic or similar impervious material. The impervious sheet will be covered with at least 3 inches of blinding material.

Joints between drain tile shall not exceed 1/8 inch except in sandy soils, where the closest possible fit must be obtained, and in organic soils where some of the more fibrous types make it desirable to slightly increase the space between tile.

Construction tolerances. The following are guidelines for subsurface drain construction:

	Conduit
Flowline or grade	+ 0.1 foot
There will be no reverse grades.	

Backfill. Backfill will be placed in such a manner as to avoid displacement of the conduit. Backfill should be moved into the trench at an angle so that material flows down the front slope of previously placed material. Backfill shall not contain frozen material, stones, clods, or objects large enough to damage the conduit. The trench should be backfilled as soon as possible after blinding.

Finish. Work areas shall be restored to their former condition as much as possible. Vegetation or other protective cover shall be established promptly in accordance with practice standard Critical Area Planting (342) when specified on the plans.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain the functional capacity of the subsurface drain. Items to consider are:

1. Keep inlets, trash guards, collection boxes and structures clean and free of materials that can reduce the flow.

2. Repair all broken or crushed lines to insure proper functioning of the drain.

3. Repair or replace broken or damaged inlets and breathers damaged by livestock or machinery.

4. Periodically inspect outlet conduit and animal guards for proper functioning.